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(54) Improved cardiovascular monitoring system.

(57) A relatively simple and practical system for detecting, recording, and processing physical and emotional parameters affecting the cardiovascular system of a subject simultaneously with the recording of the subject's EKG data. On replay, should EKG abnormalities be detected, the record is analyzed for physical activities, emotional stresses, and environmental parameters which could cause such abnormalities, so that the appropriate treatment may be selected.

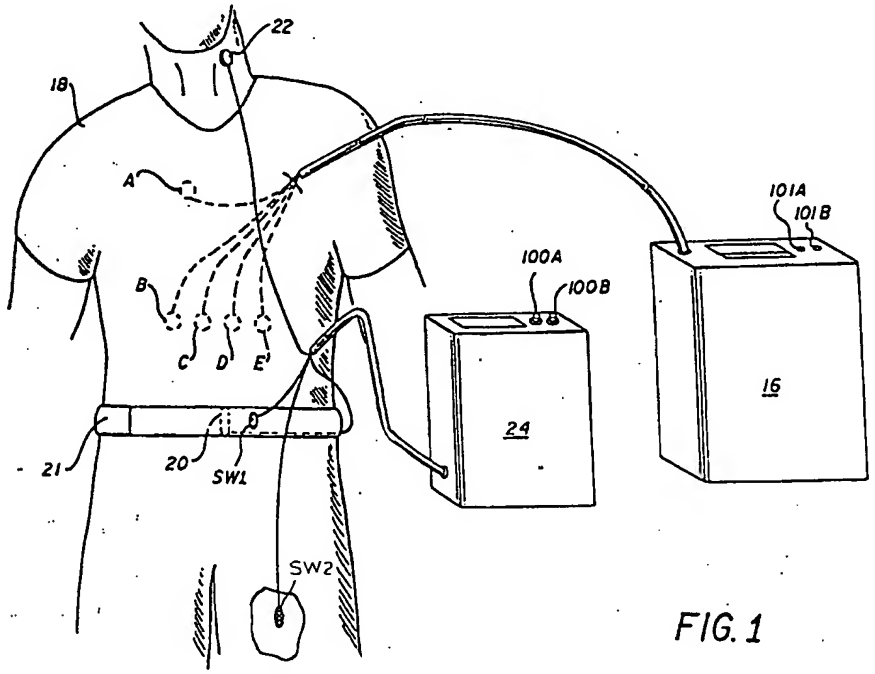

FIG. 1

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Continuous, twenty-four hour or longer, electrocardiogram (EKG) monitoring (Holter) systems are widely used in the prior art for diagnosing heart disease. However, the long term prior art EKG systems are concerned only with EKG signals which is a major shortcoming.

There is another much simpler diagnostic means used in the prior art, namely the brief exercise "stress test" in which the EKG signals are recorded during a brief time interval while the patient is exercising strenuously, for example, on a treadmill. However, this latter test is not comprehensive because exercise is only one of a number of stresses that can cause EKG abnormalities.

US Patent 4,830,021 which issued May 16, 1989 to the present inventor describes a locomotor activity monitoring system which includes EKG, and which involves long term monitoring of the patient. The system described in that patent, unlike other prior art cardiac monitoring systems, uses EKG only incidentally and primarily to monitor heart rate.

There are shortcomings in each of the prior art systems referred to above, for example, the Holter System has no detection/recording capability other than time, EKG readings and a patient marker. The patient maintains a time related diary of such events. At best, this approach is qualitative. It is also incomplete, since no data is entered, for example, when the patient is asleep. In essence, there is no objective or recorded evidence of any patient activity.

The cardiac abnormalities which are revealed by the prior art cardiac monitoring systems are equated only to physical activities. However, such cardiac abnormalities may also be revealed by a number of other conditions in the body. Knowledge of these conditions, other than physical activity, which provide detectable cardiac abnormalities is frequently important for determining the proper treatment. As noted above, such knowledge can not be acquired from current cardiac monitoring systems and techniques, and it is an object of the present invention to provide a system which also monitors such other conditions in the body.

It is well known, for example, that inadequate blood supply to the heart may alter a portion of the EKG known as the S.T. segment. It is also well known that the most common cause of inadequate blood supply to the heart is partial closure of one or more arteries by fatty formations. Limited blood flow through a narrowed artery which is inadequate to meet the needs demanded by exercise is the most common cause of such EKG changes. However, normal or slightly affected arteries may produce the same effect due to spasms from emotional upsets which are transmitted to the heart by the nervous system, and which are not detected by the prior art cardiac monitoring systems. The treatment in the case of clogged arteries is normally surgery, but a vastly different treatment is required in the case of arterial spasm caused, for example, by emotional upsets in relatively normal arteries. It follows, therefore, that even the most elaborate and complex EKG recording and analyzing systems in the prior art are incomplete.

The present invention provides a relatively simple and practical system which detects, records and processes physical and emotional parameters affecting the cardiovascular system of a subject and environmental data, simultaneously with the recording of the subject's EKG data. On replay, should EKG abnormalities be detected, the record can be analyzed for physical activities, emotional stresses, and environmental parameters which could cause such abnormalities. For example, external events known to cause cardiovascular problems, and these include, for example, such emotional stresses as real or perceived danger, anger, conflict, and the like.

The foregoing and further features of the present invention will be more readily understood from the following description of a preferred embodiment thereof, by way of example, and by reference to the accompanying drawings, of which:-

Figure 1 is a representation of a subject on which various sensors and other instruments are mounted for carrying out desired cardiac monitoring functions;

Figures 2A and 2B constitute a further representation of the subject shown in Figure 1, and show the manner in which first and second microphones are mounted on the subject for purposes to be explained, Figure 2B being a section taken along the line 2B-2B of Figure 2A; and

Figure 3 is a block diagram of a Holter replay/analysis unit which is used to receive data from recorders carried by the subject of Figure 1.

In order for the Augmented Holter Monitoring (AHM) system of the invention to perform its desired monitoring functions, it is necessary for the subject 18 of Figure 1 to carry certain sensors, transducers and other equipment. For example, the subject 18 may carry an existing miniature EKG Holter electro-magnetic recorder 16 in one of his shirt pockets. Usual EKG electrodes A-E are mounted on the subject and connected to the Holter recorder 16 over leads 17. The subject 18 also carries a miniature accelerometer 20 on a belt 21, the accelerometer measuring vertical accelerations (Gz) of the subject at his centre of gravity. The accelerations (Gz) are converted to vertical forces (Fz) by the system in a manner fully described in US Patent 4,830,021.

Two position sensor switches SW1 and SW2 are also attached to subject 18, one at his waist and the other on his thigh. Switches SW1 and SW2 may be commercially available mercury gravity switches, or other appropriate gravity switches may be used. These switches serve to provide indications of the posture of the subject, specifically whether the subject is standing, sitting or lying down. The operation of such switches is described in some detail in Patent 4,830,021.

A multiple sensor 22 is mounted on the neck of subject 18. This multiple sensor may include two microphones, as will be described, as well as light and temperature sensors. The light sensor may be a simple photodiode circuit which generates electrical signals indicative of ambient light levels. The temperature sensor may be a thermistor circuit which generates electrical signals indicative of ambient temperature. The sensors 20, 22, as well as switches SW1, SW2 are all connected to a second electro-magnetic recorder 24 which may fit into a second shirt pocket of subject 18, or which may be clipped to the Holter recorder 16. Alternatively, recorder 24 may be combined in Holter recorder 16.

As shown in Figures 2A and 2B, multiple sensor 22 includes two microphones designated Mic "A" and Mic "B". Microphones Mic "A" and Mic "B" may be sub-miniature microphones of the dynamic, electret or semiconductor type, and preferably have frequency responses in the range of 20-3000 Hz. Microphone Mic "B" is attached to the neck of subject 18 adjacent to the sterno-cleido-mastoid (SCM) muscle above the collar. Microphone Mic "B" registers strong vibrations from the voice of subject 18 (.3-3 KHz); and lower frequency vibrations due to muscle contractions of the subject occurring, for example, when the subject is asleep and is experiencing an emotional dream.

Microphone Mic "A", as best shown in Figure 2B, may be mounted on microphone Mic "B", and the microphones are acoustically isolated from one another. Microphone Mic "A" serves to register the speech of the subject as transmitted through air, and it also registers other sounds transmitted to it by air.

A Holter-type replay/analysis unit 30 is shown in Figure 3. The recorders 16 and 24 of Figure 1 are connected to unit 30 during replay, as shown, and data recorded on recorders 16 and 24 is fed into the unit. Unit 30 includes all usual components, including a computer, controls, displays, a keyboard 32 and a printer 34, all of which are needed for processing, and displaying the augmented Holter data from recorders 16 and 24. Analysis of the data from recorder 24 by unit 30 serves to yield substantial amounts of information on the activity of subject 18 of Figure 1, and of the environment surrounding the subject.

The invention provides, therefore, an improved Augmented Holter monitoring system for detecting, recording and processing parameters affecting the cardiovascular system simultaneously with the recording of EKG data, so that the patient's physical and emotional activities and environmental parameters are taken into account as causing detected EKG abnormalities.

It will be appreciated that while a particular embodiment of the invention has been shown and described, modifications may be made. It is intended in the claims to cover all modifications which come within the true spirit and scope of the invention.

Claims

1. An augmented Holter cardiovascular monitoring system (AHM) for detecting data related to physical and emotional parameters affecting the cardiovascular system of a subject, and for recording such data simultaneously with the recording of electro cardiogram (EKG) data, characterised in that it includes: first sensor means to be mounted on [a] the subject for generating EKG electric signals; second sensor means including a first sound transducer means to be mounted on the subject in a position for detecting [strong] internal vibrations of the subject in the .3-3 KHz range from the voice of the subject, and [for also detecting weaker vibrations] a second sound transducer means acoustically isolated from the first transducer means to be mounted on the subject in a position to detect vibrations in the .3-3 KHz range from external sources including external voices and for generating electric signals in response thereto; and means connected to said first and second sensor means for continuously recording the electric signals generated thereby on a long term basis.

2. The augmented Holter cardiovascular monitoring system defined in claim 1, characterised in that said [second sensor] first sound transducer means is adapted to be attached to the neck of the subject adjacent to the sterno-cleido-mastoid (SCM) muscle of the subject.

3. The augmented Holter cardiovascular monitoring system defined in claim 2, characterised in that said [second sensor] first sound transducer means [includes transducer means for detecting] also detects low frequency vibrations due to muscle contractions of the subject which occur when the subject is asleep or is experiencing an emotional dream.

4. The augmented Holter cardiovascular monitoring system defined in claim 3, characterised in that it includes third sensor means to be mounted on the subject to sense the position of the subject and to generate electric signals related thereto, said recording means being connected to said third sensor means for recording the electric signals generated thereby.

5. The augmented Holter cardiovascular monitoring system defined in claim 2, characterised in that said second sensor means includes light transducer means for generating electric signals indicative of the ambient light level.

6. The augmented Holter cardiovascular monitoring system defined in claim 1, characterised in that said second sensor means includes temperature transducer means for generating electric signals indicative of the ambient temperature.

7. The augmented Holter cardiovascular monitoring system defined in claim 1, characterised in that it includes acceleration measuring means to be mounted on the subject for generating electric signals representative of the accelerations of the subject, said recording means being connected to said acceleration measuring means.

8. The augmented Holter cardiovascular monitoring system defined in claim 7, characterised in that said acceleration measuring means is adapted to be mounted on the subject 18 in a position to measure vertical accelerations of the subject 18 substantially at the centre of gravity of the subject.

9. The augmented Holter cardiovascular monitoring system defined in claim 1, characterised in that it includes replay/analysis means 34 connected to said recording means (16, 24) for processing data recorded on said recording means (16,24).

10. A method for detecting and monitoring data related to physical and emotional parameters affecting the cardiovascular system of a subject and for recording such data on a long term continuous basis, characterised in that it comprises the following steps: mounting a first sensing means on the subject for generating EDG electric signals; mounting a first transducer means on the subject in a position for detecting internal vibrations in the .3-3 KHz range from the voice of the subject and for generating electric signals in response thereto; mounting a second sound transducer means on the subject acoustically isolated from the first transducer means in a position to detect vibrations from external sources including external voices and for generating electric signals in response thereto; and continuously recording the electric signals from said first sensor means and from said first and second sound transducer means on a long term basis.

11. The method defined in claim 1, characterised in that the first transducer means is attached to the neck of the subject adjacent to the sterno-cleido-mastoid (SCM) muscle of the subject to enable said first sound transducer to detect low frequency vibrations due to muscle contractions of the subject which occur when the subject is asleep and is experiencing an emotional dream.

12. The method defined in claim 10, and characterised in that it includes the step of mounting a second sensor means on the subject to sense the position of the subject and to generate electric signals related thereto, and for continuously recording the electric signals generated by said second sensor means on a long term basis.

13. The method defined in claim 10, characterised in that it includes mounting a light transducer means on the subject for generating electric signals indicative of the ambient light, and for continuously recording the electric signals generated by said light transducer means on a long term basis.

14. The method defined in claim 10, characterised in that it includes mounting a temperature transducer means on the subject for generating electric signals indicative of the ambient temperature, and for recording the electric signals from said temperature transducer means continuously on a long term basis.

15. The method defined in claim 10, characterised in that it includes mounting an acceleration means on the subject for generating electric signals representative of accelerations of the subject, and continuously recording the electric signals generated by said acceleration means on a long term basis.

16. The method defined in claim 15, and characterised in that it comprises mounting the acceleration measuring means on the subject in a position to measure vertical accelerations of the subject substantially at the centre of grav-

ity of the substance.

17. The method defined in claim 10, characterised in that it includes the step of processing the recorded data.

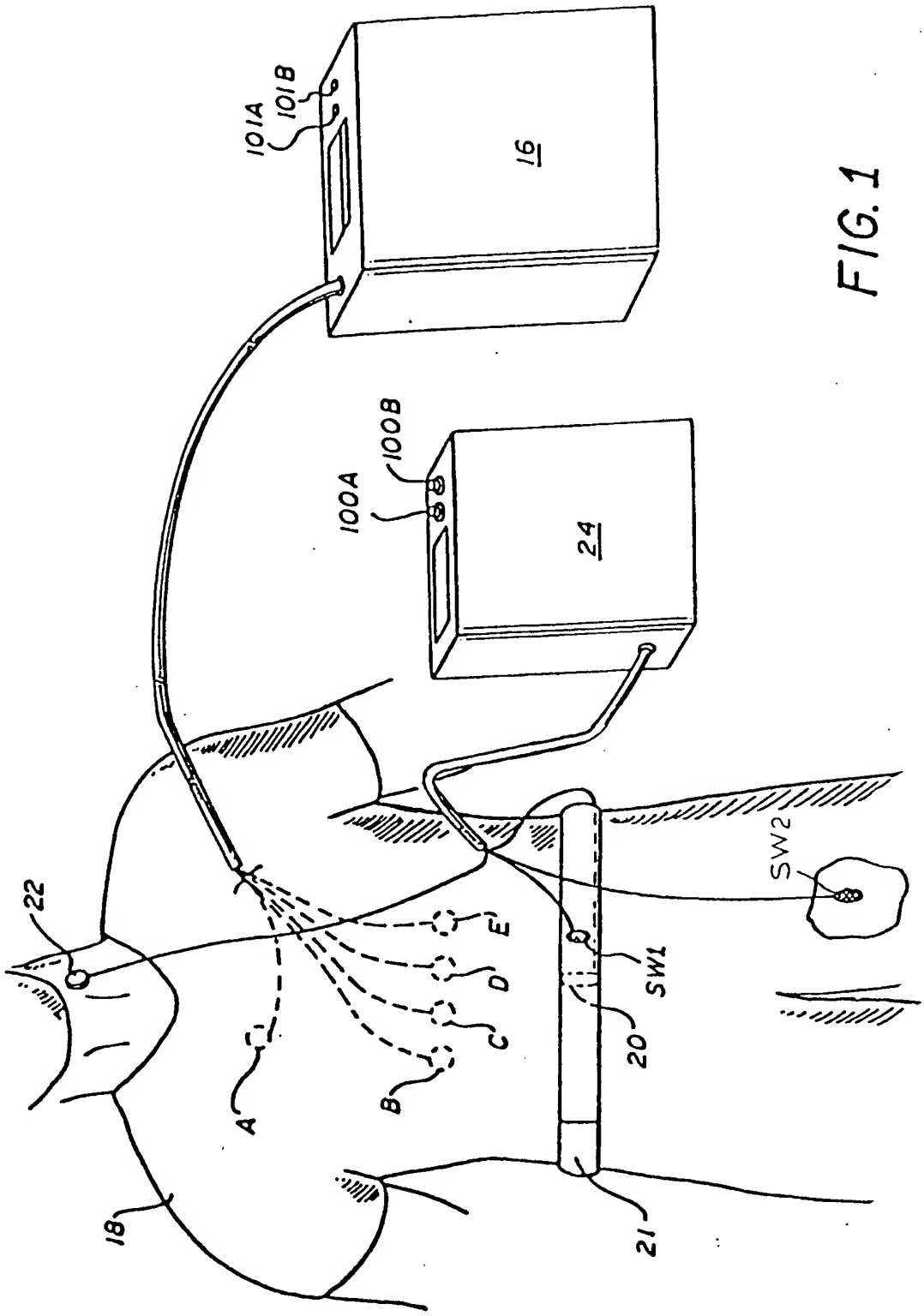


FIG. 1

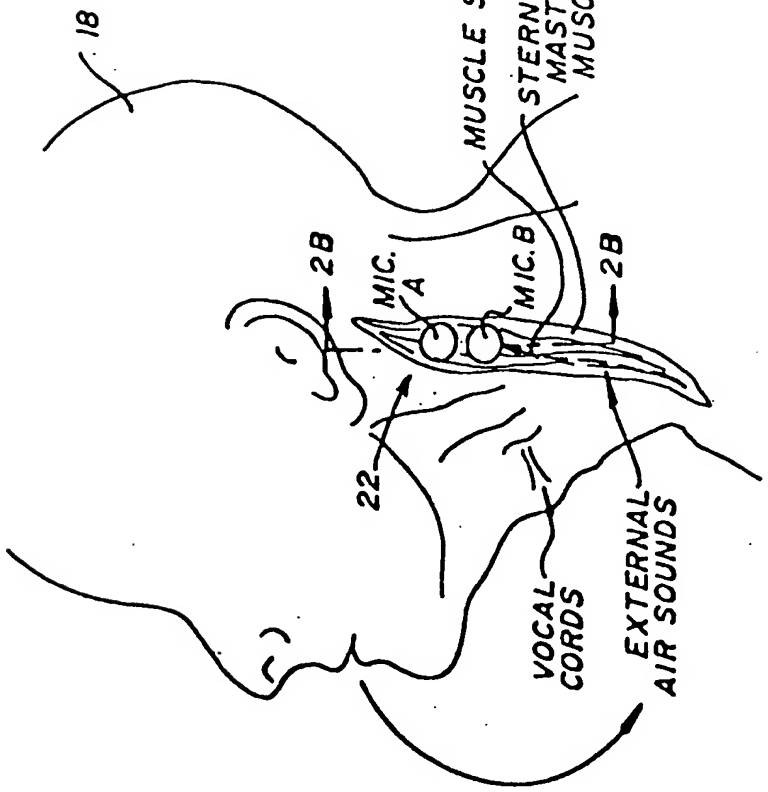

18
MUSCLE SOUNDS
STERNO-CLEIDO-MASTOID (SCM) MUSCLE
2B
MIC. A
MIC. B
2B
22
VOCAL CORDS
EXTERNAL AIR SOUNDS

FIG. 2A

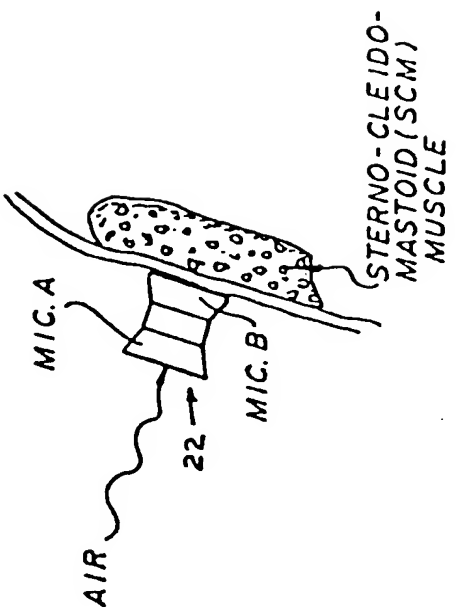
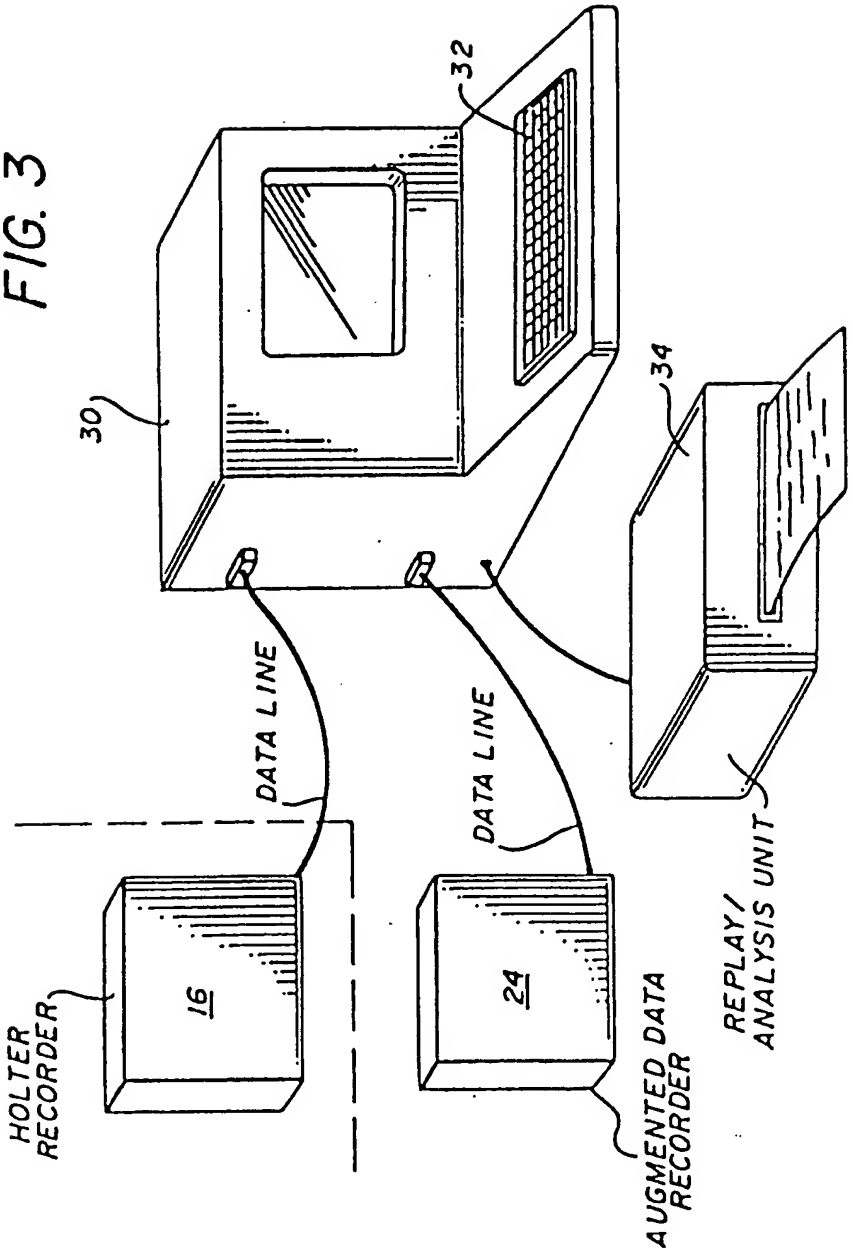

STERNO-CLEIDO-MASTOID (SCM) MUSCLE
MIC. A
MIC. B
22
AIR

FIG. 2B

FIG. 3


30
32
34
DATA LINE
DATA LINE
HOLTER RECORDER
16
24
AUGMENTED DATA RECORDER
REPLAY/ ANALYSIS UNIT

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 30 3240

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US-A-4 905 706 (B.M. DUFF et al.) * column 2, line 34 - column 3, line 49; figure 1 *	1,9,10,17	A 61 B 5/0436 A 61 B 5/22 A 61 B 7/04
A	GB-A-2 188 732 (MICRO MEDICAL) * page 2, line 41 - page 3, line 3; figure 1 *	1,10	G 10 L 3/00
P,X	US-A-4 993 421 (W.E. THORNTON) * column 4, line 8 - column 5, line 26; figures 1-3 *	1-17	
A,D	US-A-4 830 021 (W.E. THORNTON) * column 2, line 40 - column 4, line 10; figures 1-3 *	4,7,8,15, 16	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A 61 B 5/00
G 10 L 3/00

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
Berlin	09 October 91	WEIHS J.A.

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
Y: particularly relevant if combined with another document of the same catagory
A: technological background
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